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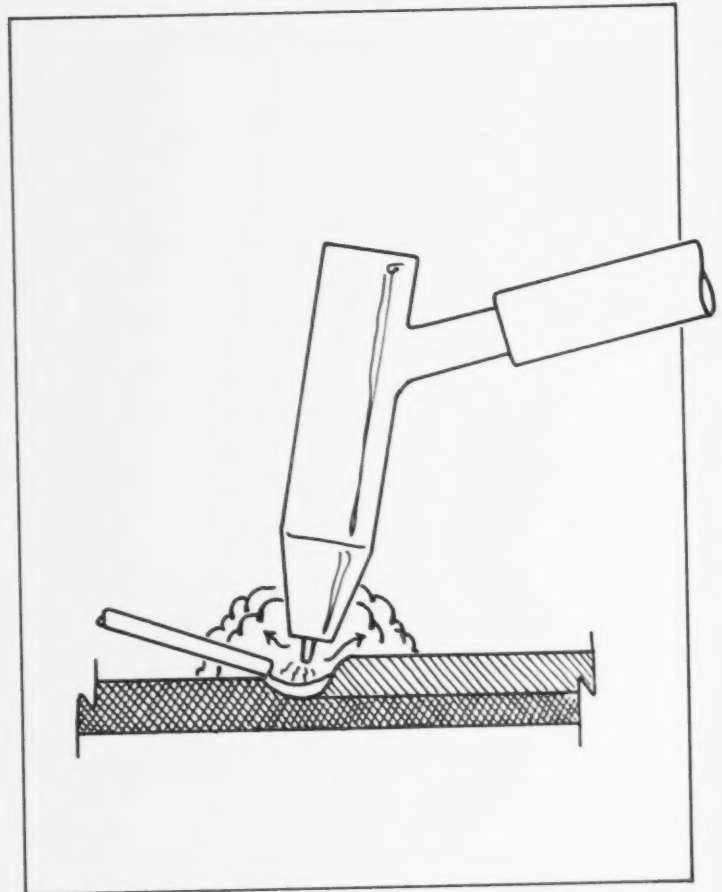
ABSTRACT

This guide is intended to assist vocational educators in teaching a three-unit module in gas tungsten arc welding. The module has been designed to be totally integrated with Missouri's Vocational Instruction Management System. The basic principles involved in gas tungsten arc welding, supplies, and applications are covered. The materials included in the module have been formatted for competency-based teaching and testing. All information sheets, transparency masters, job sheets, assignment sheets, and test items are keyed to specific competencies, and a cross-reference table has been included to aid in identifying the parts of the curriculum that relate to specific competencies. Unit tests to evaluate specific competencies have also been provided. (MN)

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ELDING • Module 6

Gas
Tungsten
Arc
Welding
(GTAW)



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Module: GTAW

Cross-Reference Table of Instructional Materials

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
J1	I 1.5, 1.6			I 1.1, 1.2			
J2	I 1.4, 1.7, 2.4, 2.5 III 1.2		I 2.1, II 1.1-1.3		III 1.1	I 18, 20-30	
J3	II 1.1-1.4				II 1.1	I 35, 38-41, II 1-6	
J4	I 2.2, II 2.1-2.3, III 1.7, 1.13				III 1.3, 1.10	I 1-13, 33, 34, 36, 37, 42-44, II 7-15	
J5	III 1.5				III 1.1		
J6	II 3.2, 3.3, III 1.6				III 1.2	II 18	
J7	II 3.1		II 3.1			II 16, 17	
J8-11	III 1.8				III 1.5		
J12,14	III 1.9				III 1.6		
J13	III 1.14				III 1.11		
J15,17	III 1.10				III 1.7		
J16	III 1.15				III 1.12		
J18,20	III 1.11				III 1.8		
J19	III 1.16				III 1.13		
J21,23	III 1.12				III 1.9		

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Module: GTAW (cont.)

Cross-Reference Table of Instructional Materials

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
J22	III 1.17				III 1.14		
J24	III 1.9				III 1.6		
J25	III 1.14				III 1.11		
J26	III 1.9				III 1.6		
J27,29	III 1.10				III 1.7		
J28	III 1.15				III 1.12		
J30,32	III 1.11				III 1.8		
J31	III 1.16				III 1.13		
J33	III 1.3, 1.4	III 1.1-1.3	III 1.1	III 1.1			
J34							Also covered in SMAW (E16) and GMAW (I33)

MODULE: GAS TUNGSTEN ARC WELDING

UNIT I: ORIENTATION

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify principles, safety guidelines and equipment associated with gas tungsten arc welding (sometimes called TIG welding). This knowledge will be evidenced by completion of the unit test to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

- 1.1 Match GTAW terms with definitions.
- 1.2 Identify true statements concerning GTAW history.
- 1.3 Select advantages, benefits and limitations of GTAW.
- 1.4 Select true statements concerning GTAW principles and applications.
- 1.5 Match terms related to GTAW safety with definitions.
- 1.6 Identify true statements concerning GTAW electrical safety.
- 1.7 Complete statements concerning important rules for handling welding cables and hoses.
- 2.1 Match GTAW terms with definitions.
- 2.2 Match GTAW machine controls with functions.
- 2.3 Complete statements concerning pulse current in GTAW.
- 2.4 Select true statements concerning how cooling systems work.
- 2.5 Identify basic parts of a GTAW torch and differentiate between gas cup or nozzle types, functions and selection criteria.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT I: ORIENTATION

CONTENTS OF THIS UNIT

- A. Objective sheets
- B. References
- C. Notes to the instructor
- D. Lesson plans
 - 1. Lesson 1: ORIENTATION AND SAFETY
 - a. Information outline
 - b. Assignment sheets
 - AS 1.1: Solve problems concerning GTAW safety
 - AS 1.2: GTAW safety
 - c. Answers to assignment sheets
 - 2. Lesson 2: EQUIPMENT
 - a. Information outline
 - b. Handout
 - HO 2.1: Cup selection for carbon and low-alloy steels
- E. Unit test
- F. Answers to unit test

REFERENCES

- A. Curriculum guide
 - 1. Fortney, Clarence, and Mike Gregory. Gas Tungsten Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. AS 1.1 is similar to an assignment sheet in Unit I of SMAW. If students do not score well on this assignment sheet, they should review safety information given in that SMAW unit, in addition to safety material in this lesson.
2. As information is discussed, point out controls on GTAW equipment in the shop.

B. Suggested student activities

1. Students can practice setting and changing machine controls for different metals.

C. Suggested supplemental references from The Media Center, State Fair Community College, Sedalia, Mo.

1. Basics of TIG Welding (W-78-130). 1978.
2. Setting the TIG Welding Machine and Welding Basic Joints (W-78-131). 1978.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT I: ORIENTATION

LESSON 1: ORIENTATION AND SAFETY

I. Terms and definitions

- A. Duty cycle--performance reference used to avoid overheating a welding machine
- B. GTAW--gas tungsten arc welding
- C. TIG--tungsten inert gas, the first name used to define the process of welding with tungsten and an inert gas shield. The name is still used frequently in place of GTAW.
- D. Heliarc®--gas-arc welding process that uses an intense electric arc struck between a nonconsumable tungsten electrode and a base metal surrounded by inert gas (helium or argon) to protect the weld zone.

NOTE: Heliarc was originally developed by Union Carbide Corporation; the term Heliarc is a registered trademark of Union Carbide.

- E. Shielding gases--inert gases (argon or helium) that are pressure-directed over a tungsten electrode and a weld zone to give protection from airborne contaminants
- F. Inert--an element or gas that has no active properties
- G. Nonconsumable--that which cannot be used up; a way of defining the tungsten electrode used in GTAW
- H. Deposition rate--the weight of filler metal placed onto or into a weld in a given period of time

II. Brief history of GTAW

- A. The first American patent for the use of an electric arc in an inert gas atmosphere was issued in 1930 to Hobart and Devers.
- B. Because the shielding gases argon and helium were so expensive and effective torch equipment was not developed, the TIG process was slow to gain popularity.
- C. The approach of World War II lent urgency to the need for a reliable process for quickly welding aluminum and magnesium on aircraft.
- D. The first patent for a tungsten inert gas torch was issued in 1942 to Russell Merideth.
- E. The first license to develop the tungsten inert gas process was granted to the Linde Company in 1942.
- F. With the increased demand for reliable welding processes brought on by World War II and the post-war improvement in electrodes, shielding gas management, torches and

cooling processes, GTAW (TIG) has continued to expand and is continually finding new applications.

III. Benefits, advantages and limitations of GTAW

A. Advantages

1. Uses no flux and does not require cleaning after the weld
2. Arc and weld puddle are clearly visible to the operator
3. Produces no slag or spatter
4. Makes excellent root pass on carbon and stainless steel pipe with back-up or back side of weld shielded with inert gas; is also excellent for repair of cast iron with phosphor bronze filler rod
5. Controlled heat concentration reduces base metal distortion, stress
6. Operator has close control of current and welding process
7. Good for thin, small or exotic materials in a variety of metals

B. Benefits from learning GTAW

1. Introduces student to nonconsumable electrodes and shielding gases
2. Helps student improve manipulative skills and eye-hand coordination
3. Adds a welding skill that students may not otherwise have an opportunity to learn
4. Provides a skilled operator with opportunities for better jobs

C. Limitations of GTAW

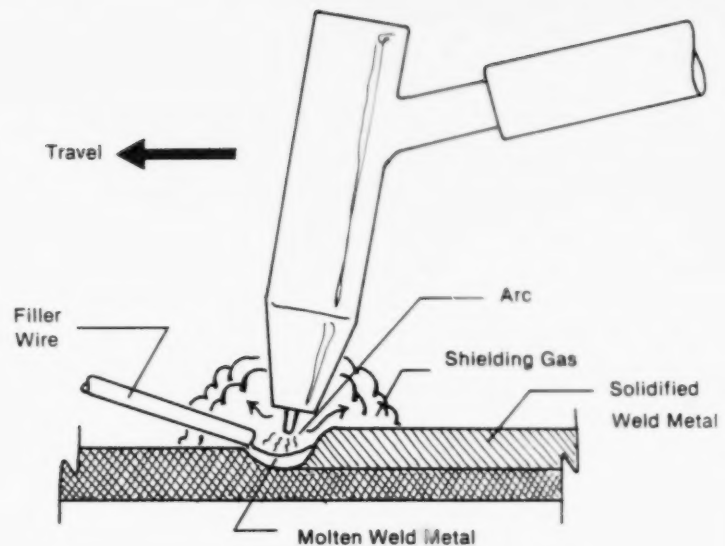
1. Will not function in a windy environment
2. Deposition is low compared with other processes
3. Slower welding speeds increase production costs

IV. GTAW principles and applications

A. Principles

1. Heat needed for fusion is generated by an arc between a nonconsumable tungsten electrode and a base metal.
2. As heat is generated from the arc, a shielding gas surrounds the arc stream and molten puddle formed by the arc. This helps stabilize the arc and protects the puddle from contaminants.

3. Filler metal can be added with a filler rod that is inserted into the weld puddle where it is protected by the shielding gas.



B. GTAW applications

1. Possible in all positions
2. Can be done on a wide range of metals and thicknesses
3. Used where precise heat control is necessary for a quality weld, such as in aircraft assembly or small, irregularly shaped objects
4. Good for almost all aluminum applications and especially good on thin aluminum and thin ferrous metal

V. Safety

- A. When using a high-frequency intensity control for GTAW, set the control at a minimum setting for the job to avoid interference.
- B. Make sure all GTAW machines using high-frequency controls have both input and output grounded to avoid erratic frequency interference.

NOTE: In production facilities where applications are numerically controlled with computerized machines, improper grounding can cause erratic interference that will alter or erase memory.

- C. Argon is much heavier than air and will quickly displace oxygen.

CAUTION: Be especially careful using the GTAW process in confined areas, even though they appear to have adequate ventilation.

- D. Select lens shade according to the manufacturer's selection chart; generally, a #11 lens shade is appropriate for GTAW.

<u>Base metal</u>	<u>Electrode size</u>	<u>Shade #</u>
Nonferrous	1/16-5/32"	11
Ferrous	1/16-5/32"	12

NOTE: When white spots are seen as after-images after removing welding hood after welding, too much light is getting through the lens. Switch to a shade at least one number darker or check the lens seal.

- E. Beware of high-frequency shock and shock from damp clothing.
- F. Position tungsten and torch so that an arc isn't struck accidentally.

VI. Duty cycle safety

- A. Duty cycle is based on a 10-minute period and the length of time during that period that a machine can be safely operated.
- B. Duty cycle is rated at the maximum output of a welding machine at a given amperage setting.
- C. A machine with a 20% duty cycle could safely operate two minutes out of each 10-minute period.

VII. Handling welding cables and hoses

- A. Disconnect and remove electrode holders and cables used for GTAW.
- B. Keep cables off metal tables or any grounding surfaces.
- C. Make sure water-cooled systems have water turned off when shutting down.
- D. Use welding cable covers.

SOLVE PROBLEMS CONCERNING GTAW SAFETY

Read the following statements carefully, then write a brief statement recommending any needed solutions.

1. A fellow student is preparing to start a GTAW job in an area where there is obviously some water on the floor. Is there a problem? _____

Solution: _____

2. A fellow student has left GTAW cables wrapped around an argon cylinder. Is there a problem? _____

Solution: _____

3. A fellow student complains that she sees white spots in front of her eyes every time she stops welding. Is there a problem? _____

Solution: _____

4. A fellow student is sanding a piece of aluminum to clean oxide from the surface and is wearing only safety glasses. Is there a problem? _____

Solution: _____

5. A fellow student complains that the fumes produced when welding at his work station are very irritating. Is there a problem? _____

Solution: _____

INSTRUCTOR'S NOTE: Completion of this assignment to specified score is the student's partial evaluation for competency J1: Demonstrate safety procedures.

ANSWERS TO ASSIGNMENT SHEET 1.1

NOTE: Student answers should approximate those given.

1. Yes. Clean up water and dry the area or cover the area with a suitable insulating material. If water-cooled, check equipment for water leaks.
2. Yes. Put cables in a safe and proper place--never on a cylinder.
3. Yes. Put a darker shade lens in the helmet or check for cracks in the lens seal.
4. Yes. Wear a face shield or a flip-type welding hood when grinding or sanding.
5. Yes. Check area for proper ventilation and have operator stand to one side of fumes.

GTAW SAFETY

Match the terms on the right with appropriate definitions.

- | | |
|--|---------------------------------------|
| ___ 1. A reduction of oxygen in the zone around a welding activity caused by any arc or flame | a. Contaminants |
| ___ 2. Poisonous gases, fumes and vapors produced by chemical displacement reactions in certain welding processes | b. Filter-type mask |
| ___ 3. Impurities formed from chemical reactions between base metals, flux and electrodes, usually present in fumes and vapors | c. Noise |
| ___ 4. Equipment necessary for safe breathing where toxic fumes are a hazard | d. Oxygen displacement |
| ___ 5. The most commonly overlooked welding work place hazard | e. Self-contained breathing apparatus |
| | ab. Toxic hazards |

Choose the letter of the option which best answers the question or completes the statement.

- ___ 6. Make sure GTAW machines using high-frequency controls have ____.
- Input and output grounds
 - A work lead to workpiece ground
 - Ground connected to machine case
 - Ground connected to building framework
- ___ 7. Which of the following is not a proper electrical safety guideline?
- Keep electrical connections tight, clean and dry.
 - Keep work area, equipment and clothing dry.
 - Dip a gun in water to cool it only in emergencies.
 - Disconnect and lock out all electric power sources before doing any work on electrical equipment.
- ___ 8. Which of the following is false?
- Since duty cycle is rated at the maximum output of a welding machine, lower-rated machines require more attention to time spent welding.
 - Duty cycle is based on a 10-minute period and the length of time during that period that a machine can be safely operated.
 - When working in high places, examine work area carefully for electrical hazards.
 - Duty cycle is a performance reference used to avoid using the wrong welding cable.
 - When using a high-frequency intensity control for GTAW, set the control at minimum.

- ___ 9. Which is an approved method of handling cables and hoses?
- a. A cable can be pulled over an obstruction.
 - b. Use gas or an oil rag to clean cables and hoses.
 - c. When not in use, cables and hoses can be coiled with some kinks in them.
 - d. Never drag cables or hoses through dirt or oil.
- ___ 10. Never drape a welding cable over any _____ ; never strike an arc on a _____ .
- a. Sharp piece of metal, non-metallic surface
 - b. Part of the body, gas cylinder
 - c. Gas cylinder, gas cylinder
 - d. Gas cylinder, non-metallic surface
- ___ 11. Gas and water hoses _____ .
- a. Can be interchanged if cleaned first
 - b. Should never be interchanged
 - c. Are the same thing
 - d. Have left-hand threads
- ___ 12. Hollow castings, tanks, drums and sealed containers should be _____ before any heating, cutting or welding activity.
- a. Filled with water
 - b. Purged with flammable gas
 - c. Purged with inert gas
 - d. None of the above
- ___ 13. Select lens shade according to the lens manufacturer's selection chart; generally, a _____ lens shade is appropriate for GTAW.
- a. #5
 - b. #7
 - c. #9
 - d. #11
- ___ 14. A general rule of thumb is that the _____ the diameter of the electrode, the _____ the number required for a lens shade.
- a. Smaller, higher
 - b. Larger, higher
 - c. Larger, smaller
 - d. None of the above
- ___ 15. Ventilation or exhaust systems capable of safely removing dangerous, irritating smoke and contaminants are needed _____ .
- a. With a few welding activities
 - b. Occasionally in the welding shop
 - c. Rarely when welding
 - d. At every work station

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's final evaluation for competency J1: Demonstrate safety procedures.

ANSWERS TO ASSIGNMENT SHEET 1.2

1. d
2. ab
3. a
4. e
5. c
6. a
7. c
8. d
9. d
10. c
11. b
12. c
13. d
14. c
15. d

MODULE: GAS TUNGSTEN ARC WELDING

UNIT I: ORIENTATION

LESSON 2: EQUIPMENT

I. Terms and definitions

- A. Ar--abbreviation for argon shielding gas
- B. He--abbreviation for helium shielding gas
- C. Cfh--cubic feet per hour, the standard by which the flow rate of shielding gases is measured
- D. Contamination--process whereby a weld becomes unacceptable because of improper displacement of a shielding gas or the presence of oil, moisture or oxides on a base metal or filler rod
- E. EWP--tungsten electrode of 99.5% purity that has a relatively low current-carrying capacity with AC power and a low resistance to contamination. It is less expensive than other types of tungsten electrodes and is used in less critical applications.
- F. EWTh--tungsten electrode with a small amount of thorium added for greater current-carrying capacity, longer life and greater resistance to contamination. It is frequently preferred for welding stainless steel.

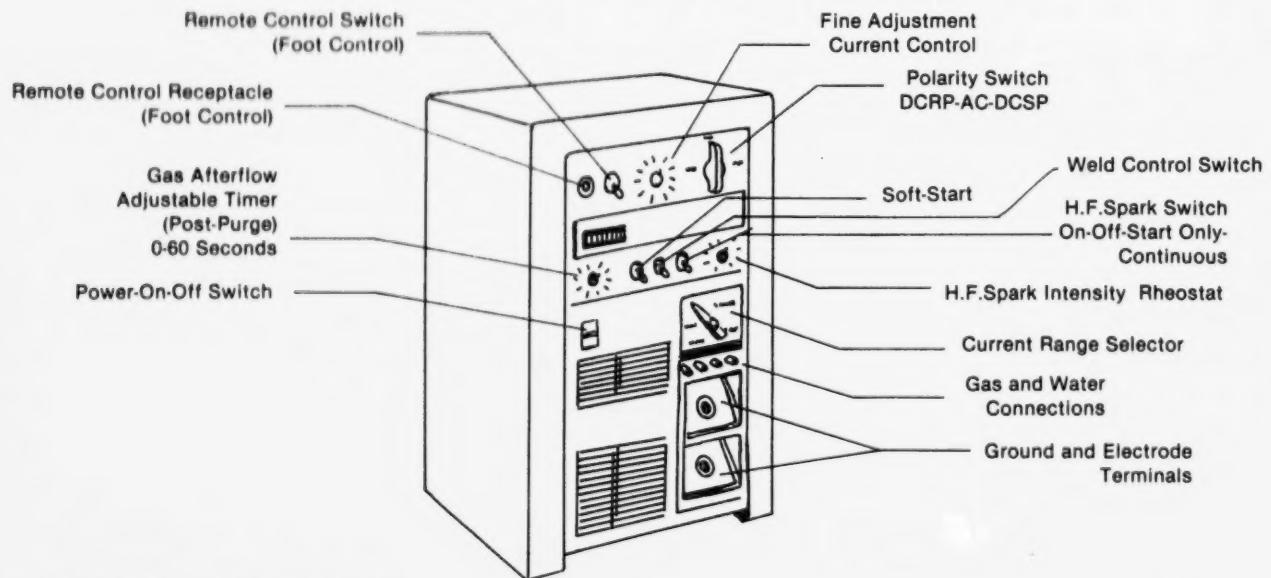
NOTE: EWTh electrode classifications are EWTh-1, EWTh-2 and EWTh-3, to indicate the percentage of thorium in the electrode. EWTh-3 has a lateral segment throughout its length that contains 1%-2% thorium.

- G. EWZr--tungsten electrode with some zirconium added for better performance characteristics in certain types of AC welding. It is frequently preferred for welding aluminum.
- H. Amps--current amount or flow rate of electrons in a welding circuit
- I. Volts--amount of force required to force a current through a given resistance in a welding circuit

II. GTAW machine controls and functions

- A. The high frequency control functions as a pilot arc to bridge the gap between the electrode and base metal, eliminating the need for scratch-starting the arc.
- B. The post flow switch permits shielding gases to continue flowing around the electrode after the arc is extinguished, eliminating contamination of the electrode and the weld puddle while cooling.
- C. Current selectors (amperage controls)
 - 1. The current range selector provides a general range of amperage selections such as low, medium, high or maximum. It should never be changed while welding.

2. The fine adjustment current control provides a specific amperage selection from minimum to high in low range, minimum to high in medium range, etc.
- D. Polarity switches provide quick adjustment for desired polarity, DCRP, AC and DCSP. It should never be changed while welding.
- E. The start adjustment control (soft-start switch) reduces current during starting to help eliminate burning the tungsten electrode or burning through thin gauge metals.
- F. The high-frequency spark switch turns high frequency on or off. It provides adjustment of spark intensity for start only or continuous operation.
- G. High-frequency spark rheostats provide adjustment of spark intensity for start only or continuous operation.
- H. Remote control switches allow switching to foot-hand operation or panel operation.
- I. The weld control switch selects SMAW or GTAW welding sources.



III. Pulse current and use in GTAW

- A. Some welding machines have a special setting called "pulse mode" or "pulse."
- B. This setting is used to regulate current so that it establishes a heat-cool pattern that is in timed segments or pulses.
- C. This pulsing action minimizes heat build-up in the base metals--especially thin base metals--and results in minimum distortion and better welds.

IV. Types and function of GTAW systems

- A. Air cooled systems are usually suitable for light-duty welding that does not exceed 150 amps but cannot be used for lengthy periods of continuous welding.

B. Water cooled systems are required for heavy-duty, continuous welding. They frequently use tap water as a coolant but can use anti-freeze or a water-soluble oil in a self-contained system.

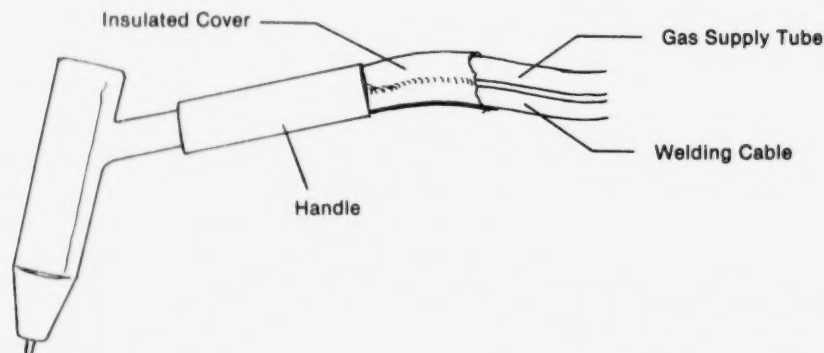
C. Function

1. Some have a fail-safe device that will not allow the welding circuit to be completed until the cooling system is functioning at a required level.
2. Some systems have water-flow safety controls so that, should the coolant supply diminish, the electrical power source is shut off.
3. Some systems have clear plastic tubing built into the supply lines so the circulating liquid can be monitored visually by the operator.
4. All systems should be checked during set-up and monitored periodically during operation to avoid damage to equipment.

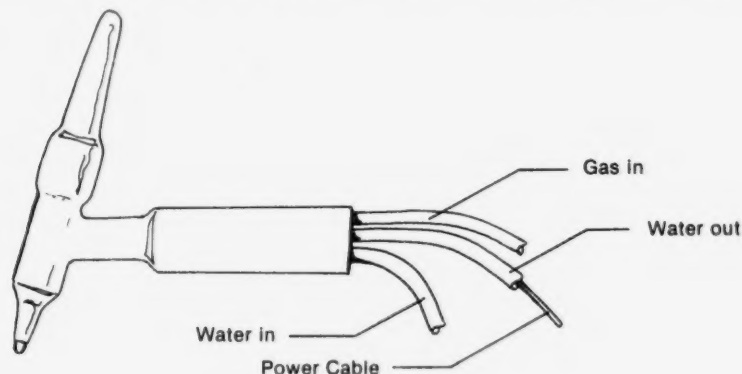
VI. Power cable and torch parts

A. Power cables

1. Air cooled cables have separate gas and electric lines encased in a single insulated cover.



2. Water cooled cables have separate power, gas, and water-in and water-out lines. The water-out and power cables are usually encased in a single insulated cover.

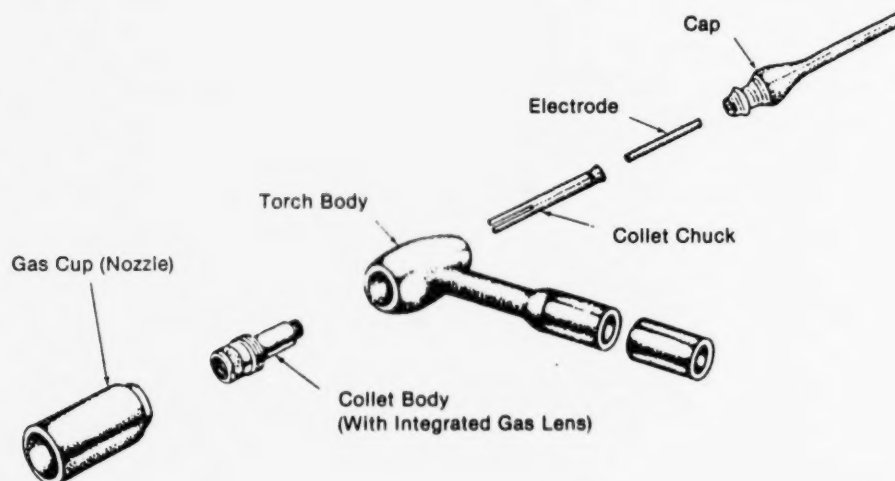


GTAW 19

B. GTAW torch

1. The cap holds and tightens tungsten electrode in collet.
2. The electrode acts as a nonconsumable conductor of the welding current.
3. Collet chucks are used to guide, center and hold electrodes.
4. The torch body provides housing for electrode, collet chuck and collet body, and fitting ends for gas and water supplies.
5. The collet body holds collet chuck and electrode, diffuses shielding gas and anchors gas cup, which may have an integrated gas lens.
6. Gas cups or nozzles are nozzle-type devices that directs the flow of shielding gas around the electrode and into the weld zone to prevent contamination.
 - a. Ceramic cups are most commonly used because of low cost.
 - b. Pyrex cups (clear-glass) allow a welder to see through when good visibility of the weld zone is required.
 - c. Metal cups are usually copper and are used where application might break ceramic or pyrex cups.
 - d. Alumina cups are made of high-strength aluminum to give high-impact resistance and long life.
 - e. When selecting the proper cup, determine metal thickness, joint design, welding position and amperage (HO 2.1).

NOTE: A rule of thumb is to select a cup that is three times the diameter of the electrode used. It should be equal or just a bit larger than the molten weld puddle.

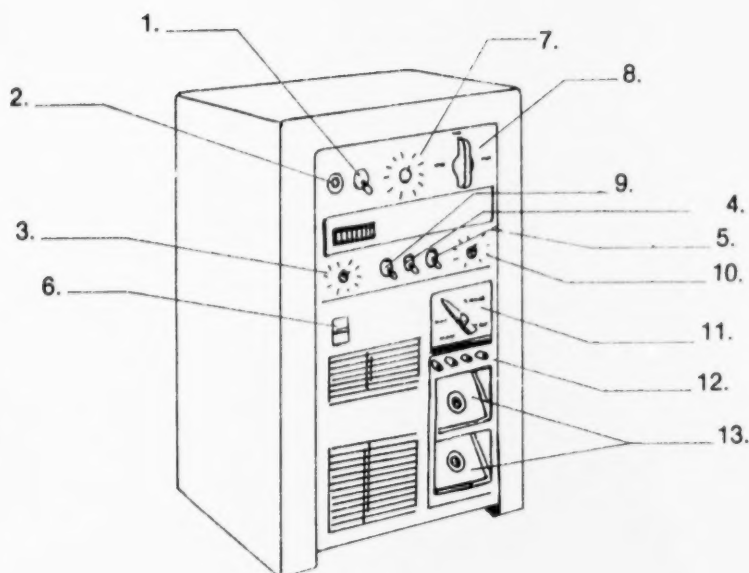


MODULE: GAS TUNGSTEN ARC WELDING

UNIT I: ORIENTATION

UNIT TEST

Match GTAW machine controls with functions.



- a. Current range selector
- b. Fine adjustment current control
- c. Gas afterflow adjustable timer
- d. Gas and water connections
- e. Ground and electrode terminals
- ab. High-frequency spark intensity rheostat
- ac. High-frequency spark switch
- ad. Polarity switch
- ae. Power on-off switch
- bc. Remote control receptacle
- bd. Remote control switch
- be. Start adjustment control (soft-start)
- cd. Weld control switch

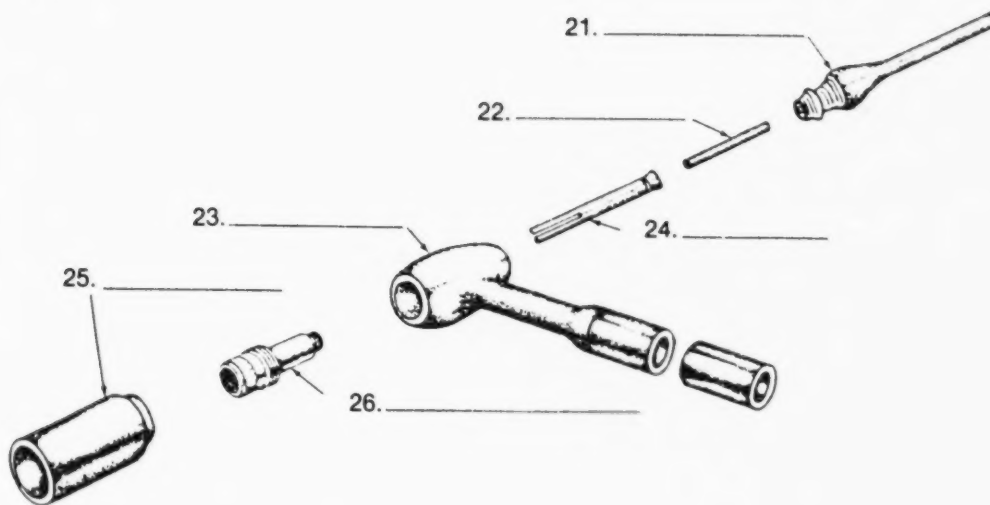
Choose the option which best answers the question or completes the statement.

___ 14. Which is not true of GTAW history?

- a. Inexpensive argon and helium and effective, plentiful torch equipment helped the TIG process catch on quickly.
- b. World War II added urgency to the need for a quick, reliable welding process on aircraft aluminum and magnesium.
- c. The first patent for a tungsten inert gas torch was issued in 1942 to Russell Merideth.
- d. The first license to develop the tungsten inert gas process was granted to the Linde Company in 1942.

- ____ 15. What is the advantage of using GTAW?
- a. It uses no flux and requires only brushing after the weld.
 - b. Arc and weld puddle do not need to be monitored.
 - c. Only light slag and spatter are produced.
 - d. Operator has close control of current and welding process.
 - e. GTAW is good for thick, large or exotic materials in a variety of metals.
- ____ 16. Limitations of GTAW include ____.
- a. Non-function in a windy environment
 - b. Low deposition as compared with other processes
 - c. Slower welding speeds
 - d. All of the above
 - e. None of the above
- ____ 17. How does a student benefit from learning GTAW?
- a. Introduction to nonconsumable electrodes
 - b. Improved manipulative skills and eye-hand coordination
 - c. Additional welding skill
 - d. Opportunities for higher-paying jobs
 - e. All of the above
- ____ 18. Which best describes pulse settings on GTAW machines?
- a. Standard GTAW machine equipment
 - b. Regulates current so that an on-off pattern in timed segments or pulses is established
 - c. Maximizes heat input in base metals
 - d. Results in minimum distortion and better welds
- ____ 19. Which statement is false?
- a. Some cooling systems have a fail-safe device that will not allow the welding circuit to be completed until the cooling system functions at a required level.
 - b. Some cooling systems have water-flow safety controls.
 - c. Some systems have clear plastic tubing built into the supply lines.
 - d. Most systems should be checked during set-up and monitored periodically during operation.
- ____ 20. Which describes a GTAW principle?
- a. Heat generated by arc between nonconsumable tungsten electrode and base metal
 - b. Shielding gas surrounds the arc stream and molten puddle
 - c. Filler can be added with a filler rod
 - d. All of the above

Identify basic parts of a GTAW torch.



- | | |
|-----------------|----------------------|
| a. Cap | d. Electrode |
| b. Collet body | e. Gas cup or nozzle |
| c. Collet chuck | ab. Torch body |

___ 27. Which type of gas cup or nozzle is most commonly used because it does an adequate job and is the least expensive?

- | | |
|------------|------------|
| a. Pyrex | c. Ceramic |
| b. Alumina | d. Metal |

___ 28. Which type of gas cup is of clear glass?

- | | |
|------------|------------|
| a. Pyrex | c. Ceramic |
| b. Alumina | d. Metal |

___ 29. Which kind of cup gives high-impact resistance and long life?

- | | |
|------------|------------|
| a. Pyrex | c. Ceramic |
| b. Alumina | d. Metal |

___ 30. When selecting the proper gas cup, determine ____.

- Metal thickness
- Joint design
- Welding position
- Amperage
- All of the above

- ___ 31. Which does not describe an application of GTAW?
- a. Possible in all positions
 - b. Can be done on a wide range of metals and thicknesses
 - c. Good for almost all thin materials except aluminum
 - d. Used where precise heat control is necessary
 - e. None of the above

Match the terms on the right with appropriate definitions.

- | | |
|--|---------------------|
| ___ 32. Abbreviation for gas tungsten arc welding | a. Amps |
| ___ 33. The first--and still frequently used--name identifying the process of welding with tungsten and an inert gas shield | b. Ar |
| ___ 34. Gas-arc welding process that uses an intense electric arc struck between a nonconsumable tungsten electrode and a base metal (with a shielding gas) | c. Cfh |
| ___ 35. Inert gases that are directed under pressure over a tungsten electrode and a weld zone | d. Contamination |
| ___ 36. That which cannot be used up; a way of defining the tungsten electrode used in GTAW | e. Deposition rate |
| ___ 37. Weight of filler metal placed onto or into a weld in a given period of time | ab. EWP |
| ___ 38. Abbreviation for argon shielding gas | ac. EWTh |
| ___ 39. Abbreviation for helium shielding gas | ad. EWZr |
| ___ 40. Cubic feet per hour, the standard by which the flow rate of shielding gases is measured | ae. GTAW |
| ___ 41. Process whereby a weld becomes unacceptable because of improper movement of a shielding gas or the presence of oil, moisture or oxides on a base metal or filler rod | bc. He |
| ___ 42. A less-expensive tungsten electrode of 99.5% purity that has a relatively low current-carrying capacity with AC power and a low resistance to contamination | bd. Heliarc |
| ___ 43. Tungsten electrode with a small amount of thorium added for improved current-carrying capacity, life and contamination resistance | be. Nonconsumable |
| ___ 44. Tungsten electrode with some zirconia added to give it better performance characteristics in certain types of AC welding | cd. Shielding gases |
| ___ 45. Amount of current or rate of flow of electrons in a welding circuit | ce. TIG |
| ___ 46. Amount of force required to propel current through a given resistance in a welding circuit | de. Volts |

INSTRUCTOR'S NOTE: Completion of this unit test to specified score is the student's partial evaluation for competencies J2-4.

ANSWERS TO UNIT TEST

1. bd (J4)
2. bc (J4)
3. c (J4)
4. cd (J4)
5. ac (J4)
6. ae (J4)
7. b (J4)
8. ad (J4)
9. be (J4)
10. ab (J4)
11. a (J4)
12. d (J4)
13. e (J4)
14. a
15. d
16. d
17. e
18. d (J2)
19. d
20. d (J2)
21. a (J2)
22. d (J2)
23. ab (J2)

24. c (J2)
25. e (J2)
26. b (J2)
27. c (J2)
28. a (J2)
29. b (J2)
30. e (J2)
31. c
32. ae
33. ce (J4)
34. bd (J4)
35. cd (J3)
36. be (J4)
37. e (J4)
38. b (J3)
39. bc (J3)
40. c (J3)
41. d (J3)
42. ab (J4)
43. ac (J4)
44. ad (J4)
45. a
46. de

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

UNIT OBJECTIVES

Upon completion of this unit, students should be able to identify different shielding gases, tungsten and filler metals. They should also be able to determine when to use a particular consumable. This knowledge will be evidenced by completion of the job sheet and unit test to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

- 1.1 Select true statements concerning GTAW shielding gases.
- 1.2 Complete statements concerning flow rates for shielding gases.
- 1.3 Complete statements concerning flow meter operation.
- 1.4 Set up a flow meter regulator for GTAW shielding gases.
- 2.1 Complete statements concerning tungsten electrode applications and identification.
- 2.2 Complete statements concerning tungsten electrode preparation.
- 2.3 Identify proper electrode stickout lengths.
- 3.1 Complete statements concerning filler metal selection and use.
- 3.2 Select true statements concerning requirements for base metal preparation.
- 3.3 Identify potential contamination problems.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

CONTENTS OF THIS UNIT

- A. Objective sheet
- B. References
- C. Notes to the instructor
- D. Lesson plans
 - 1. Lesson 1: SHIELDING GASES
 - a. Information outline
 - b. Handouts
 - HO 1.1: GTAW operating data for carbon steel
 - HO 1.2: GTAW operating data for stainless steel
 - HO 1.3: GTAW operating data for aluminum
 - c. Job sheet
 - JS 1.1: Set up a flow meter regulator for GTAW shielding gases
 - 2. Lesson 2: TUNGSTEN ELECTRODES
 - a. Information outline
 - 3. Lesson 3: FILLER METALS
 - a. Information outline
 - b. Handout
 - HO 3.1: Filler metals data
- E. Unit test
- F. Answers to unit test

REFERENCES

- A. Curriculum guide
 - 1. Fortney, Clarence, and Mike Gregory. Gas Tungsten Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested student activities

1. Students must practice changing cups, electrodes, collets and collet bodies to become skillful.
2. Instruct students on sharpening electrodes, cleaning metals and correct design and fit-up.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

LESSON 1: SHIELDING GASES

I. GTAW shielding gases and characteristics

A. Argon

1. Most popular gas for GTAW
2. Good availability
3. Provides better shielding at lower flow rates than helium since argon is 10 times heavier than helium
4. Provides an easier arc start than helium
5. Provides better cleaning action when welding aluminum with AC

B. Helium

1. Frequently used for welding thicker metals
2. Gives a higher heat than argon for comparable current
3. Requires precise control of arc length
4. Provides faster welding speeds than argon
5. Produces poor arc stability and cleaning action
6. Can be combined in an argon-helium mix to provide high heat input and excellent cleaning on thicker gauge metals

II. Flow rates for shielding gases (HO 1.1-1.3)

A. Flow rates are measured in cubic feet per hour as set and controlled through a flow meter.

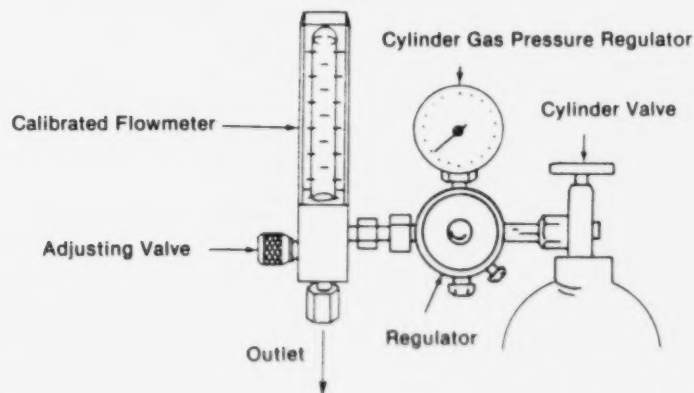
B. Flow rates vary according to the following conditions.

1. Metal thickness
2. Joint design
3. Tungsten electrode diameter
4. Filler rod diameter
5. Amperage

6. Gas selection
7. Travel speed and angle
8. Environmental conditions

III. Flow meter operation

- A. Close adjusting valve
- B. Flow meters are specifically designed to regulate the flow of low-pressure gases as measured in cubic feet per hour (cfh) rather than pounds per square inch (psi).
- C. Floating-ball type flow meters must be operated only in the vertical position.
- D. A flow meter should always be used with a regulator between the gas supply and the flow meter to assure uniform input pressure to the flow meter.



GTAW OPERATING DATA FOR CARBON STEEL

MILD STEEL . . . MANUAL WELDING . . . DIRECT CURRENT — STRAIGHT POLARITY						
Metal Thickness	Joint Type	Tungsten Electrode Diameter	Filler Rod Diameter (If Required)	Amperage	GAS	
					Type	Flow-CFH
1/16"	Butt	1/16"	1/16"	60-70	Argon	15
	Lap	1/16"	1/16"	70-90	Argon	15
	Corner	1/16"	1/16"	60-70	Argon	15
	Fillet	1/16"	1/16"	70-90	Argon	15
1/8"	Butt	1/16-3/32"	3/32"	80-100	Argon	15
	Lap	1/16-3/32"	3/32"	90-115	Argon	15
	Corner	1/16-3/32"	3/32"	80-100	Argon	15
	Fillet	1/16-3/32"	3/32"	90-115	Argon	15
3/16"	Butt	3/32"	1/8"	115-135	Argon	20
	Lap	3/32"	1/8"	140-165	Argon	20
	Corner	3/32"	1/8"	115-135	Argon	20
	Fillet	3/32"	1/8"	140-170	Argon	20
1/4"	Butt	1/8"	5/32"	160-175	Argon	20
	Lap	1/8"	5/32"	170-200	Argon	20
	Corner	1/8"	5/32"	160-175	Argon	20
	Fillet	1/8"	5/32"	175-210	Argon	20

Courtesy of Miller Electric Mfg. Co.

HO1.1

GTAW OPERATING DATA FOR STAINLESS STEEL

STAINLESS STEEL . . . MANUAL WELDING . . . DIRECT CURRENT — STRAIGHT POLARITY						
Metal Thickness	Joint Type	Tungsten Electrode Diameter	Filler Rod Diameter (If Required)	Amperage	GAS	
					Type	Flow-CFH
1/16"	Butt	1/16"	1/16"	40-60	Argon	15
	Lap	1/16"	1/16"	50-70	Argon	15
	Corner	1/16"	1/16"	40-60	Argon	15
	Fillet	1/16"	1/16"	50-70	Argon	15
1/8"	Butt	3/32"	3/32"	65-85	Argon	15
	Lap	3/32"	3/32"	90-110	Argon	15
	Corner	3/32"	3/32"	65-85	Argon	15
	Fillet	3/32"	3/32"	90-110	Argon	15
3/16"	Butt	3/32"	1/8"	100-125	Argon	20
	Lap	3/32"	1/8"	125-150	Argon	20
	Corner	3/32"	1/8"	100-125	Argon	20
	Fillet	3/32"	1/8"	125-150	Argon	20
1/4"	Butt	1/8"	5/32"	135-160	Argon	20
	Lap	1/8"	5/32"	160-180	Argon	20
	Corner	1/8"	5/32"	135-160	Argon	20
	Fillet	1/8"	5/32"	160-180	Argon	20

Courtesy Miller Electric Mfg. Co.

GTAW OPERATING DATA FOR ALUMINUM

ALUMINUM MANUAL WELDING — ALTERNATING CURRENT — HIGH FREQUENCY						
Metal Thickness	Joint Type	Tungsten Electrode Diameter	Filler Rod Diameter (If Required)	Amperage	GAS	
					Type	Flow-CFH
1/16"	Butt	1/16"	1/16"	60-85	Argon	15
	Lap	1/16"	1/16"	70-90	Argon	15
	Corner	1/16"	1/16"	60-85	Argon	15
	Fillet	1/16"	1/16"	75-100	Argon	15
1/8"	Butt	3/32-1/8"	3/32"	125-150	Argon	20
	Lap	3/32-1/8"	3/32"	130-160	Argon	20
	Corner	3/32-1/8"	3/32"	120-140	Argon	20
	Fillet	3/32-1/8"	3/32"	130-160	Argon	20
3/16"	Butt	1/8-5/32"	1/8"	180-225	Argon	20
	Lap	1/8-5/32"	1/8"	190-240	Argon	20
	Corner	1/8-5/32"	1/8"	180-225	Argon	20
	Fillet	1/8-5/32"	1/8"	190-240	Argon	20
1/4"	Butt	5/32-3/16"	3/16"	240-280	Argon	25
	Lap	5/32-3/16"	3/16"	250-320	Argon	25
	Corner	5/32-3/16"	3/16"	240-280	Argon	25
	Fillet	5/32-3/16"	3/16"	250-320	Argon	25

Courtesy of Miller Electric Mfg. Co.

SET UP A FLOW METER REGULATOR FOR GTAW SHIELDING GASES

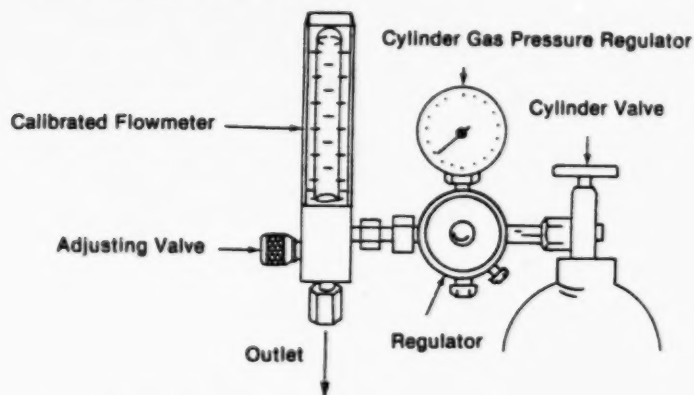
Equipment:

GTAW machine and accessories
 Argon or helium cylinder
 Flow meter regulator
 Adjustable wrench or 1 1/8" open-end wrench
 Safety glasses

Procedure:

Evaluation
 3 2 1 N

1. Check that gas cylinder is safely secured in an upright position. Remove cylinder cap. Crack cylinder valve slightly to clear cylinder valve fitting. — — — —
2. Attach flow meter regulator vertically to the cylinder valve. Tighten regulator fitting nut with wrench, but do not over-tighten. — — — —
3. Check to make sure that flow meter adjusting valve is shut off. If it isn't, turn it clockwise until tight. — — — —



4. Stand to one side and open gas cylinder valve all the way so that it will back seat against the top valve. — — — —
5. Set up and turn on GTAW machine. Check with instructor for appropriate procedures. — — — —
6. Turn flow meter adjusting valve counter-clockwise until the ball starts to rise in the flow meter. If ball is not rising, depress foot pedal or check post flow timer. — — — —
7. Move the adjusting valve clockwise or counter-clockwise to make adjustment to CFH desired. — — — —
8. NOTE: The very top of the ball is the reference point for measuring CFH. Ask instructor to check your work. — — — —

8. Ask instructor to check your work.

— — — —

9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.

— — — —

Average of above evaluations*

— — — —

*This average is the student's final evaluation for competency J3: Identify, select and safely handle shielding gases.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

LESSON 2: TUNGSTEN ELECTRODES

I. Tungsten electrodes and applications

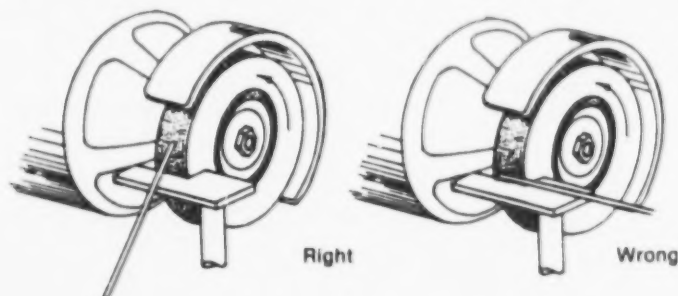
Type of Electrode	Color	Finish	Sizes (")	Applications
Pure	Green	Ground or cleaned	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	Aluminum and magnesium
1% thoriated	Yellow	Ground or cleaned	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	Aluminum and carbon (mild) or stainless steel
2% thoriated	Red	Ground or cleaned	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	Aluminum and carbon (mild) or stainless steel
Zirconiated	Brown	Ground or cleaned	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	X-ray quality for alum. or magnesium

II. Tungsten electrode preparation

- A. A tungsten electrode for DC welding should be ground on a taper to a fine point when used in low amperage starting or on very thin metal.
- B. On DC applications where a fine point might melt off into the deposit, the electrode should be tapered to a blunt point.
- C. The taper should be 2-2 1/2 times the diameter of the electrode.



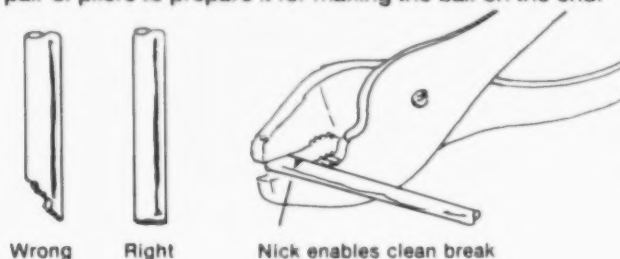
- D. Tungsten electrodes should be ground on a fine-grit, hard-abrasive grinding wheel used only for tungsten electrodes help avoid contamination.
- E. A tungsten electrode should always be ground lengthwise with the electrode—not crosswise, which restricts current flow and causes other weld problems.



- F. Tungsten electrodes used for AC welding should have a ball or half-oval shaped end that is equal to or no larger than 1 1/2 times the diameter of the electrode.

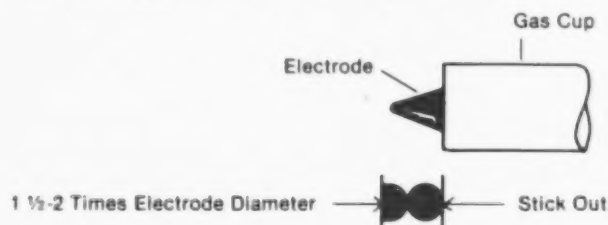


- G. Pure tungsten electrodes used on aluminum normally forms the proper ball end in the welding process.
- H. To get a ball end on a thoriated tungsten electrode requires striking an arc on a piece of copper with the high frequency on "start only" in reverse polarity with a low amp setting.
- I. A tungsten electrode for AC welding should be nicked on a grinding wheel, then broken clean with a pair of pliers to prepare it for making the ball on the end.



III. Electrode stickout

- A. A tungsten electrode should stick out beyond the torch nozzle or cup a distance equal to about 1 1/2 times the electrode's diameter.



- B. Once electrode stickout is properly adjusted, hand-tighten the cap of the torch to secure electrode.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

LESSON 3: FILLER METALS

- I. Filler metal selection and use (HO 3.1)
 - A. Filler metal should be compatible with base metal.
 - B. Type and size of filler metal should be selected according to type and thickness of base metal.
 - C. Care should be taken to keep filler metals clean and free of contamination whether in storage or in use.
 - D. The hot end of the filler wire or rod should not be removed from the protection of the gas-shielded zone during the welding operation.
- II. Requirements for base metal preparation
 - A. Remove mill scale, dirt and paint from all surfaces with a portable sander.
 - B. Normal surface oxides can be removed with a stainless steel brush.
 - C. Heavy oxides, grease and oil should be removed with a shop rag moistened with a combination cleaner that will degrease and deoxidize at the same time.
 - D. Anytime solvents are used for cleaning, they should be allowed to dry before welding starts.

CAUTION: Many solvent cleaners and deoxidizers are highly flammable and should be used with care.
 - E. Fit-up is critical in GTAW; joint preparation should be uniform with no irregularities or gaps.
 - F. Welding should begin as soon as possible after the base metal has been prepared to eliminate the chance of air-borne contaminants adhering to the metal.
- III. Special problems with contamination and air movement
 - A. Metals that are not properly cleaned before welding starts will immediately contaminate a tungsten electrode, make welding difficult or impossible and waste valuable time.
 - B. Work areas that are unclean add to the potential for contaminants to slow or stop the welding process.
 - C. Air movement across the weld zone blows the away shielding gas and contributes to immediate contamination of the weld zone.
 - D. Work areas should be checked for drafts and cross-ventilation that could blow away shielding gas. Screens or deflectors should be erected around the work area.

FILLER METALS DATA**AWS specifications for filler metals suitable for GTAW**

<u>Spec. no.</u>	<u>Title</u>
A 5.2	Iron and steel gas-welding rods
A 5.7	Copper and copper-alloy bare welding rods and electrodes
A 5.9	Corrosion-resisting chromium and chromium-nickel steel bare and composite metal-cored and stranded arc welding electrodes and welding rods
A 5.10	Aluminum and aluminum-alloy welding rods and bare electrodes
A 5.13	Surfacing welding rods and electrodes
A 5.14	Nickel and nickel-alloy bare welding rods and electrodes
A 5.16	Titanium and titanium-alloy bare welding rods and electrodes
A 5.18	Mild steel electrodes for GMAW
A 5.19	Magnesium-alloy welding rods and bare electrodes
A 5.21	Composite surfacing welding rods and electrodes
A 5.24	Zirconium and zirconium-alloy bare welding rods and electrodes

MODULE: GAS TUNGSTEN ARC WELDING

UNIT II: SUPPLIES

UNIT TEST

Select the option which best answers the question or completes the statement.

- ___ 1. In GTAW, argon is used as a shielding gas because it ____.
- a. Gives higher heat for comparable current
 - b. Provides better cleaning action when welding aluminum with AC
 - c. Provides faster welding speeds
 - d. Requires precise control of arc length
- ___ 2. Helium is used in GTAW as a shielding gas because it ____.
- a. Gives higher heat for comparable current
 - b. Provides better cleaning action when welding aluminum with AC
 - c. Provides an easier start
 - d. Provides better shielding at lower flow rates
 - e. All of the above
- ___ 3. Flow rates are measured in ____.
- a. Pounds per square inch
 - b. Cubic feet per hour
 - c. Metric gradations
 - d. Standard liquid measures
- ___ 4. Flow rates vary according to ____.
- a. Metal thickness
 - b. Joint position
 - c. Tungsten electrode tip configuration
 - d. Filler rod length
- ___ 5. Which is not a true statement concerning flow meter operation?
- a. Close adjusting valve.
 - b. Flow meters are specifically designed to regulate the flow of high-pressure gases in cubic feet per minute (cfm).
 - c. Floating-ball type flow meters must be operated only in the vertical position.
 - d. A flow meter should always be used with a regulator between the gas supply and the flow meter.
- ___ 6. Which type of tungsten electrode is yellow in color?
- a. Pure
 - b. 1% thoriated
 - c. 2% thoriated
 - d. Zirconiated

- ___ 7. Which type of tungsten electrode is of X-ray quality?
- a. Pure
 - b. 1% thoriated
 - c. 2% thoriated
 - d. Zirconiated
- ___ 8. Which type of tungsten electrode can be used only on aluminum and magnesium?
- a. Pure
 - b. 1% thoriated
 - c. 2% thoriated
 - d. Zirconiated
- ___ 9. On _____ applications where there is a chance that a fine point might melt off into the deposit, the electrode should be ____.
- a. DC, tapered to a blunt point
 - b. AC, tapered to a blunt point
 - c. AC, ground flat
 - d. DC, ground flat
- ___ 10. The taper should be equal in length to _____ times the diameter of the electrode.
- a. 1-1 1/2
 - b. 1 1/2-2
 - c. 2-2 1/2
 - d. 2 1/2-3
- ___ 11. Tungsten electrodes should be ground _____ on a _____, hard, abrasive grinding wheel.
- a. Crosswise, coarse-grit
 - b. Lengthwise, fine-grit
 - c. Crosswise, fine-grit
 - d. Lengthwise, coarse-grit
- ___ 12. Tungsten electrodes used for _____ welding should have a ball or half-oval shaped end that is equal to or no larger than _____ times the diameter of the electrode.
- a. DC, 1 1/2
 - b. DC, 2 1/2
 - c. AC, 2 1/2
 - d. AC, 1 1/2
- ___ 13. How is a ball-shaped end formed on a thoriated tungsten electrode?
- a. Strike arc on carbon with the high frequency on "start only".
 - b. Strike arc on copper with the high frequency on "start only" in reverse polarity with a low amp setting.
 - c. Strike arc on copper with the high frequency on a medium setting.
 - d. Use reverse polarity with a high amp setting.
- ___ 14. A tungsten electrode should stick out beyond the torch nozzle or cup a distance of about _____ times the electrode's diameter.
- a. 3 1/2
 - b. 2 1/2
 - c. 2
 - d. 1 1/2

- ___ 15. The torch cap should be ___ to secure electrode.
- Hand-tightened after stickout is properly adjusted
 - Wrench-tightened after stickout is properly adjusted
 - Hand-tightened before stickout is properly adjusted
 - Hand- or wrench-tightened
- ___ 16. Filler metal should be ___ base metal and ____.
- Compatible with, free of contamination
 - Exactly the same as, free of contamination
 - Compatible with, dry
 - Exactly the same as, dry
- ___ 17. The hot end of the filler wire or rod _____ removed from the protection of the gas-shielded zone during welding.
- Can sometimes be
 - Should be only slightly
 - Should not be
 - Is frequently
- ___ 18. Which is not a requirement for base metal preparation?
- Remove mill scale, dirt and paint from all surfaces with a portable sander.
 - Normal surface oxides can be removed with any wire brush.
 - Heavy oxides, grease and oil should be removed with a shop rag moistened with a combination cleaner that will degrease and deoxidize at the same time.
 - Any time solvents are used for cleaning, they should be allowed to dry before welding starts.
 - Fit-up is critical in GTAW, and joint preparation should be fairly close.
- ___ 19. Which statement is false?
- Welding should begin as soon as possible after the base metal has been prepared.
 - Metals that are not properly cleaned before welding starts will immediately contaminate a tungsten electrode, make welding difficult or impossible and waste valuable time.
 - Work areas that are unclean will add to the potential for contaminants to slow or stop the welding process.
 - Air movement across the weld zone blows the shielding gas away, but contamination is not a real problem if the air is clean.
 - Work areas should be checked for drafts and cross ventilation that could blow shielding gas away.

ANSWERS TO UNIT TEST

1. b (J3)
2. a (J3)
3. b (J3)
4. a (J3)
5. b (J3)
6. b (J3)
7. d (J4)
8. a (J4)
9. a (J4)

10. c (J4)
11. b (J4)
12. d (J4)
13. b (J4)
14. d (J4)
15. a (J4)
16. a (J7)
17. c (J7)
18. b (J6)
19. d

MODULE: GAS TUNGSTEN ARC WELDING

UNIT III: APPLICATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to weld ferrous and nonferrous metals in all positions with the gas tungsten arc welding process. This knowledge will be evidenced by completion of job sheets and the unit test to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

- 1.1 Arrange in order the steps in manual welding with a filler rod.
- 1.2 Select true statements concerning backup bars uses in GTAW.
- 1.3 Identify characteristics of a good weld.
- 1.4 Identify causes of poor welds.
- 1.5 Set up and shut down GTAW equipment.
- 1.6 Prepare carbon and stainless steel for GTAW.
- 1.7 Prepare a tungsten electrode for welding carbon and stainless steel.
- 1.8 Make stringer beads on carbon and stainless steel with or without filler metal in the various positions.
- 1.9 Weld joints to specifications on carbon and stainless steel in the flat position.
- 1.10 Weld joints to specifications on carbon and stainless steel in the horizontal position.
- 1.11 Weld joints to specifications on carbon and stainless steel in the vertical position.
- 1.12 Weld joints to specifications on carbon and stainless steel in the overhead position.
- 1.13 Prepare a tungsten electrode for welding nonferrous metals.
- 1.14 Weld joints to specifications on aluminum in the flat position.
- 1.15 Weld joints to specifications on aluminum in the horizontal position.
- 1.16 Weld joints to specifications on aluminum in the vertical position.
- 1.17 Weld joints to specifications on aluminum in the overhead position.

MODULE: GAS TUNGSTEN ARC WELDING

UNIT III: APPLICATIONS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TECHNIQUES

a. Information outline

b. Transparency masters

TM 1.1: Elements of a good weld

TM 1.2: Causes of poor welds

TM 1.3: Causes of poor welds (cont.)

c. Handout

HO 1.1: Troubleshooting guide

d. Assignment sheet

AS 1.1: GTAW techniques

e. Job sheets

JS 1.1: Set up and shut down GTAW equipment

JS 1.2: Prepare metal for GTAW

JS 1.3: Prepare a tungsten electrode for welding carbon and stainless steel

JS 1.4: Getting started

JS 1.5: Make stringer beads on carbon and stainless steel with or without filler metal in various positions

JS 1.6: Weld joints to specifications on carbon and stainless steel in the flat position

JS 1.7: Weld joints to specifications on carbon and stainless steel in the horizontal position

JS 1.8: Weld joints to specifications on carbon and stainless steel in the vertical position

JS 1.9: Weld joints to specifications on carbon and stainless steel in the overhead position

JS 1.10: Prepare a tungsten electrode for welding nonferrous metals

JS 1.11: Weld joints to specifications on aluminum in the flat position

JS 1.12: Weld joint to specifications on aluminum in the horizontal position

JS 1.13: Weld joints to specifications on aluminum in the vertical position

JS 1.14: Weld joints to specifications on aluminum in the overhead position

REFERENCES

A. Curriculum guide

1. Fortney, Clarence, and Mike Gregory. Gas Tungsten Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Invite a manufacturer's representative to talk to the students about the uses of GTAW welding and give a demonstration of its versatility.

B. Suggested student activities

1. Arrange a tour of a local or area welding or fabrication shop that uses GTAW in production work. Students can observe applications and techniques, giving class reports on their observations.
2. Arrange for students to attend a local AWS or other professional meeting or seminar devoted to discussion of GTAW techniques, new equipment and new procedures in the field.
3. For practice, have students run some vertical joint beads down, as well as up. For cost efficiency, students can practice sharpening electrodes using steel or stainless steel filler metal.

C. Suggested supplemental materials from The Media Center, State Fair Community College, Sedalia, Mo.

1. Out-of-Position TIG Welding (W-79-132). 1979.

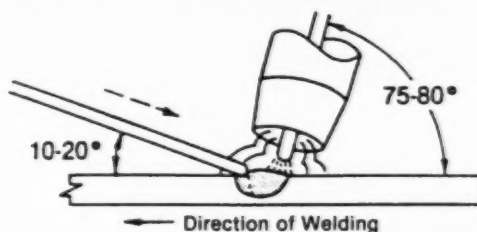
MODULE: GAS TUNGSTEN ARC WELDING

UNIT III: APPLICATIONS

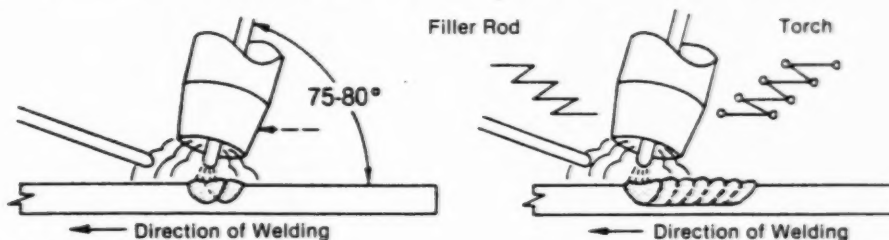
LESSON 1: TECHNIQUES

I. Steps in manual welding with a filler rod

- A. Select and prepare tungsten electrode, adjust stickout and adjust machine controls.
- B. Move the torch so that tungsten electrode comes within $1/8"$ to $1/16"$ of base metal. Strike arc and adjust to desired length.
- C. Hold torch perpendicular to base metal and make very slight circular motions until a bright, fluid puddle forms.
- D. Move the torch back from the puddle away from the direction of travel and angle it 75-80 degrees.
- E. Insert filler metal rod at a 10- to 20-degree angle into the leading edge of the molten pool and let a drop or two of molten metal fill the puddle.



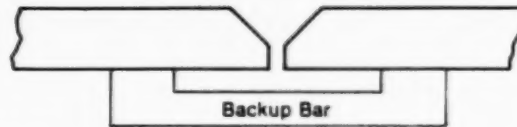
- F. Withdraw the filler rod from the puddle, being sure to keep the end of the rod in the shielded zone.
- G. Move torch back to the leading edge of the puddle and repeat the procedure.



II. Backup bars

- A. On certain GTAW applications, backup bars may be required to physically support the joint and the weld puddle.
- B. Backup bars also serve to protect the backside of a weld from contamination and to "chill" or draw heat away from the weld zone.

- C. Copper backup bars are more commonly used and are frequently grooved directly below the joint to provide an area where a purging gas can be directed to further protect the weld's backside from contamination in critical applications.



III. Judging a good weld (TM 1.1)

- A. Clean and bright
- B. Even ripple
- C. Smooth edge
- D. Uniform width and correct bead size
- E. Good, even penetration

IV. Troubleshooting poor welds (TM 1.2, 1.3, HO 1.1)

- A. Welding current too low
- B. Welding current too high
- C. Arc too long and voltage too high
- D. Welding speed too fast
- E. Welding speed too slow

ELEMENTS OF A GOOD WELD

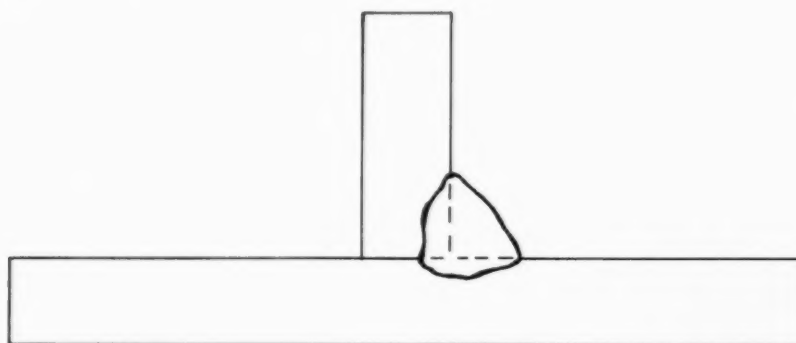
Result:

- Proper build-up
- Good appearance
- Good penetration
- Bead edges fused in



Result:

- No undercut
- Legs of fillet weld equal to metal thickness
- Slightly convex bead face



CAUSES OF POOR WELDS

Problem:

- Excessive build-up
- Poor penetration
- Poor fusion at edges

Cause:

Welding current too low



Problem:

- Bead too wide and flat
- Undercut at edges
- Excessive burn through

Cause:

Welding current too high



Problem:

- Bead too small
- Insufficient penetration
- Ripples widely spaced

Cause:

Travel speed too fast



CAUSES OF POOR WELDS (CONT.)

Problem:

- Bead too high
- Excessive build-up
- Excessive penetration

Cause:

Travel speed too slow

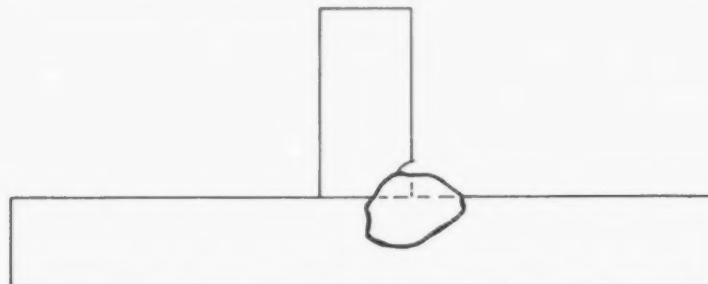


Problem:

- Undercut
- Insufficient weld deposit
- Uneven penetration

Cause:

Welding current too high and/or wrong placement of filler rod



Problem:

- Poor penetration
- Poor fusion

Cause:

Faulty joint preparation and too low welding current



TROUBLESHOOTING GUIDE

Wasteful electrode consumption can result from several causes. Check for improper shielding, improper size of electrode for current required, electrode contamination or electrode oxidation during cooling. Also, verify that the power source is not operating on reverse polarity and that the electrode holder is not overheating.

To remedy shielding problems, clean the nozzle, bring it closer to the work or step up gas flow. Use a larger electrode, removing any contaminated portions. To eliminate electrode oxidation during cooling, keep gas flowing after stoppage of arc for at least 10-15 seconds. (Rule: one second for each 10 amperes) For excessive heating, use ground-finish electrodes, change the collet or check for improper collet contact.

Erratic arcs are the result of dirty or greasy base metal, too-narrow joints, a contaminated electrode, an electrode that is too large in diameter or a too-long arc.

Alleviate base metal problems by using appropriate chemical cleaners, a wire brush or abrasives. For narrow joints, open the joint groove, move the electrode toward work or decrease voltage. If a too-large electrode is suspected, use ground-finish electrodes, change collets or check for improper collet contact.

Porosity in the finished work can be caused by entrapped gas impurities (hydrogen, nitrogen, air, water vapor), use of old acetylene hoses, interchanging of gas and water hoses, or an oil film on the base metal.

To rectify, blow out air from all lines before striking an arc, remove condensed moisture from lines or use welding grade (99.99%) inert gas. Only new hoses should be used since acetylene penetrates the hose, contaminating it for other uses. Never interchange water and gas hoses. (Color coding helps.) With oil films, clean base metal with a chemical cleaner not prone to breaking up in the arc. Do not weld while base metal is wet!

Tungsten contamination of the workpiece can result when contact starting with an electrode, when an electrode melts and alloys with base metal, or when an electrode shatters from thermal shock.

Instead of contact starting, use a high-frequency starter or a copper striker plate. With electrode melting, use less current, a larger electrode, or a thoriated or zirconium-tungsten electrode. If shattering is a problem, make certain electrode ends are not slivered or cracked when using high current values. Use embrittled tungsten to facilitate clean, easy breakage.

Credit: Sacks, Raymond J. Welding: Principles and Practices. Peoria, Ill.: Bennett & McKnight Publishing Co., 1981, pg. 786.

GTAW TECHNIQUES

Arrange in order the steps in manual welding with a filler rod.

- | | | | |
|--------|-----|-----|---|
| ___ 1. | 1st | a. | Hold torch perpendicular to base metal and make very circular motions until a bright, fluid puddle forms. |
| ___ 2. | 2nd | b. | Move torch back to leading edge of the puddle and repeat the procedure. |
| ___ 3. | 3rd | c. | Select and prepare tungsten electrode, adjust stickout and adjust machine controls. |
| ___ 4. | 4th | d. | Move the torch so that tungsten electrode comes within 1/8" to 1/16" of base metal. Strike arc and adjust to desired length. |
| ___ 5. | 5th | e. | Insert filler metal rod at a 10- to 20-degree angle into the leading edge of the molten pool and let a drop or two of molten metal fill the puddle. |
| ___ 6. | 6th | ab. | Move the torch back from the puddle away from the direction of travel and angle it 75-80 degrees. |
| ___ 7. | 7th | ac. | Withdraw the filler rod from the puddle, being sure to keep the end of the rod in the shielded zone. |

Choose the option which best completes the statement or answers the question.

- ___ 8. On some GTAW applications, backup bars may be required to _____.
 a. Protect the backside of a weld from contamination
 b. Physically support the joint
 c. Support the weld puddle
 d. "Chill" or draw heat away from the weld zone
 e. All of the above
- ___ 9. Which type of backup bar is more commonly used?
 a. Flat copper
 b. Flat steel
 c. Grooved copper
 d. Grooved steel
- ___ 10. What makes up a good weld?
 a. Clean and dull
 b. Even ripple
 c. Porous edge
 d. Graduated width and bead size
 e. Shallow, even penetration
- ___ 11. Poor welds are caused by _____.
 a. Arc too slow, voltage high
 b. Current too low or high
 c. Arc too short, voltage high
 d. None of the above

- ___ 12. GTAW filler rod and torch movement is like that used in ____ .
- a. Oxy-fuel
 - b. GMAW
 - c. Carbon-arc or plasma cutting
 - d. SMAW
- ___ 13. What problem is caused by entrapped gas impurities, interchanging of gas and water hoses or an oil film on base metal?
- a. Tungsten contamination of workpiece
 - b. Erratic arc
 - c. Wasteful electrode consumption
 - d. Porosity
- ___ 14. Using a high frequency starter and a copper striker plate are remedies to correct which problem?
- a. Tungsten contamination of workpiece
 - b. Erratic arc
 - c. Wasteful electrode consumption
 - d. Porosity

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's final evaluation for competency J33: Identify welding problems, their causes and take corrective action.

ANSWERS TO ASSIGNMENT SHEET 1.1

1. c
2. d
3. a
4. ab
5. e
6. ac
7. b
8. e
9. c
10. b (J33)
11. b (J33)
12. a
13. d (J33)
14. a (J33)

SET UP AND SHUT DOWN GTAW EQUIPMENT

Equipment:

GTAW machine with accessories
 Personal safety clothing and equipment
 Shielding gas
 Safety glasses
 Tungsten (for carbon and stainless steel)
 Coolant (for nonferrous metal)
 Tungsten electrode (for nonferrous metal)
 Brass ground clamp (for nonferrous metal)

Specifications for nonferrous metal:

Tungsten: pure or zirconiated
 Electrical characteristics: AC, high-frequency continuous

Procedure:

Evaluation
 3 2 1 N

1. Set up power supply. Set current range selector according metal thickness. Set polarity switch to DCSP (carbon or stainless) or AC (nonferrous). Set weld control switch to GTAW.
2. Set high frequency switch to "start only" (carbon and stainless) or "continuous" position (nonferrous).
3. Set spark control for soft start. Set remote control switch for contactor or amperage control to remote or panel, depending on machine accessories.
4. Set post flow timer according to electrode size. Turn on cylinder valve and adjust flow meter regulator to rate of flow recommended for electrode.
5. Check for proper and complete circulation in the cooling system and verify that there are no leaks.
6. Select correct size collet body, collet chuck and gas cup according to electrode size.
7. For carbon and stainless steel, prepare tungsten with a pointed tip. For nonferrous metals, prepare tungsten with a ball tip.

NOTE: Refer to JS 1.3 and JS 1.10 for tip preparation.

8. Adjust electrode stickout.
9. Attach ground clamp to base metal. Switch on machine.

- | | |
|---|---------|
| 10. Ask instructor to check results of set-up procedure. | — — — — |
| 11. Prepare for shut-down procedure. Close gas cylinder valve. Depress foot control to bleed gas line. | — — — — |
| 12. Shut off flow meter regulator, cooling system and power switch. | — — — — |
| 13. Remove electrode from torch and return to proper storage. Remove collet, collet chuck and gas cup and return to proper storage. | — — — — |
| 14. Disconnect ground clamp. Roll cables up neatly. As directed by instructor, prepare for next job sheet or clean up area. | — — — — |
| Average of above evaluations* | — — — — |

*This average is the student's final evaluation for competency J5 and J2.

PREPARE METAL FOR GTAW**Equipment:**

Personal safety clothing
 Safety glasses and face shield
 Portable grinder and sanding attachment
 Metal, as approved by instructor
 Clean shop rags

For carbon and stainless steel:

Wire brush
 Combination cleaner-deoxidizer
 Pliers and clamps

For nonferrous metal:

Clamps or vise
 File
 Degreasing and deoxidizing solution

Procedure:**Evaluation****3 2 1 N**

1. Secure workpiece with clamps or vise. Remove all scale, rust, dirt, and paint from all surfaces with portable sander.	—	—	—	—
2. For nonferrous metal, remove oxide with stainless steel brush. For carbon or stainless steel, use wire brush or stainless steel brush as required.	—	—	—	—
3. With nonferrous metal, moisten a shop rag with cleaning solution and wipe plate. Wash stainless steel with a solution of cleaner-deoxidizer and allow to air dry before welding.	—	—	—	—
4. Wipe carbon steel down with a clean, dry shop rag. Store in a dry place and weld as soon as possible after cleaning.	—	—	—	—
5. Ask instructor to check your work.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency J6: Identify joint design and prepare material for weld procedure.

PREPARE A TUNGSTEN ELECTRODE FOR WELDING CARBON AND STAINLESS STEEL

Equipment:

Personal safety clothing and equipment
Safety glasses and face shield
Pedestal grinder
Minimum 120-grit grinding wheel, dressed
Pliers
Tungsten, 1-2% thoriated

Procedure:

Evaluation
3 2 1 N

- | | |
|--|---------|
| 1. Determine diameter of electrode. Measure or estimate a distance equal to 2 1/2 times the diameter of the electrode to serve as a guide for length of point. | — — — — |
| 2. Turn grinder on and allow wheel to reach full rpm. Hold the electrode firmly and place it gently against the grinder so that direction of grinding will run in the direction of the length of the electrode and not crosswise to the length. | — — — — |
| CAUTION: Manipulate the electrode with your fingers and don't allow the end of the electrode to jab the palm of your hand. | |
| 3. Twist the tungsten slowly as you grind to give a uniform bevel to the grind. Keep the point of the electrode at the center. | — — — — |
| 4. Leave the needle point on the electrode if the job application calls for low amperage starting on thinner gauge metals. Dull the point slightly on the grinding wheel if the job application calls for higher amperage on thicker gauge metals. Turn off grinder. | — — — — |
| 5. Ask instructor to check your work. | — — — — |
| NOTE: If electrode appears to be contaminated or improperly prepared, break off the end with a pair of pliers and grind the point again. | |
| 6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — — — — |
| Average of above evaluations* | — — — — |

*This average is the student's partial evaluation for competency J4: Identify, select, shape and install tungsten electrode.

GETTING STARTED

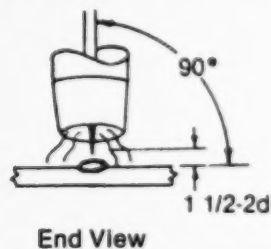
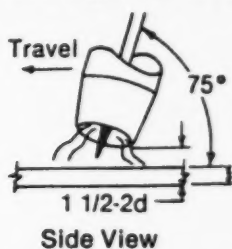
NOTE: This job sheet is provided for initial set-up with nearly all of the following job sheets in this unit.

Equipment:

GTAW machine with accessories
 Personal safety clothing and equipment
 Tungsten electrode to specifications
 Shielding gas to specifications
 Nonferrous metal or carbon and stainless steel, as approved by instructor
 Stainless steel wire brush
 Pliers
 Safety glasses

Procedure:

1. Set up equipment as outlined earlier. Double check electrode stickout.
2. Position plate in accordance with specifications and hold torch with dominant hand. Move torch so that cup rests on base metal with electrode about $3/16"$ off base metal.
3. Lower welding hood and depress foot control until arc jumps the gap and is established. Correct electrode angle as soon as arc is established.



4. Preheat the starting point until a small molten puddle is formed.

MAKE STRINGER BEADS ON CARBON AND STAINLESS STEEL WITH OR WITHOUT FILLER METAL IN VARIOUS POSITIONS

Specifications:

Filler metal: If applicable, carbon and stainless steel per instructor

Tungsten: 1-2% thoriated (carbon or stainless), pure or zirconiated (nonferrous)

Shielding gas: He or Ar

Electrical: DC - high frequency "start only" (carbon or stainless), "continuous" (nonferrous)

Position: flat

Technique: Steady forward motion

Cleaning: brush (nonferrous)

Testing: visual

References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

- | | |
|--|---------|
| 1. Perform JS 1.4. | _ _ _ _ |
| 2. If using filler rod, follow this procedure. | _ _ _ _ |
| a. Move rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle. | |
| b. Withdraw filler rod about 1/2" from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the rod's end in the shielded area. | |
| c. Advance the puddle forward while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc, letting a drop or two of molten filler metal fill the puddle. | |
| d. Until stringer is completed, repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod. | |
| 3. If welding without filler rod, move electrode slowly in the direction of travel, maintaining correct arc length, bead width and electrode angle. (The bead should penetrate the plate but should <u>not</u> cause burn-through.) | _ _ _ _ |
| 4. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of the weld. | _ _ _ _ |
| 5. Place torch in a secure, safe place. | _ _ _ _ |
| 6. Secure plate with pliers and visually inspect for good penetration with no burn-through, uniform bead width with neat appearance, and even bead ripples. | _ _ _ _ |

- | | |
|--|---------|
| 7. Ask instructor to check your work. | — — — — |
| 8. Continue making practice passes as directed by your instructor. Visually inspect each pass and have instructor check your work. | — — — — |
| 9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — — — — |
| Average of above evaluations* | — — — — |

*This average is the student's final evaluation for competency J8: Build pad of beads in flat position.

INSTRUCTOR'S NOTE: Use the checklist below to evaluate the student on beads made in the horizontal, vertical and overhead positions. Completion of beads in each position to specified score is the student's final evaluation for competencies J9-11.

- | | |
|---|-----------------------|
| Visual inspection of product: | Evaluation
3 2 1 N |
| 1. Uniform in width, chill rings, etc. | — — — — |
| 2. No defects, such as undercut or cold lap | — — — — |
| 3. Straightness of weld | — — — — |
| 4. Obvious penetration | — — — — |
| Average of above evaluations* | — — — — |

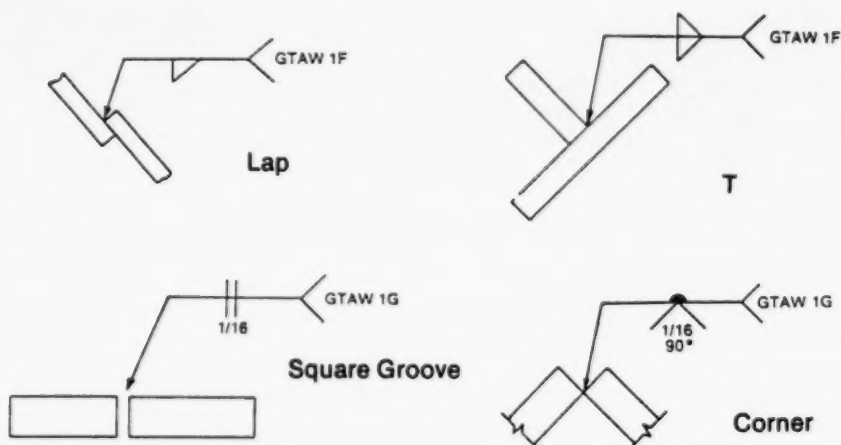
WELD JOINTS TO SPECIFICATIONS ON CARBON AND STAINLESS STEEL IN THE FLAT POSITION

Equipment:

Filler metal, as approved by instructor (open-root corner joint)
1/16" gap wire (open-root corner joint)

Specifications:

Joint designs and weld symbols



Filler metal: carbon or stainless steel as per instructor

Tungsten: 1-2% thoriated

Shielding gas: He or Ar

Electrical: DC - high frequency set on start only

Positions: 1F, 1G

Technique: steady forward motion

Testing: visual

References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure:

1. Perform JS 1.4.
2. For fillet welds, tack weld plates on both ends for specified joint. For open-root joints, use a 1/16" gap wire and place plates into position. Tack weld both ends.

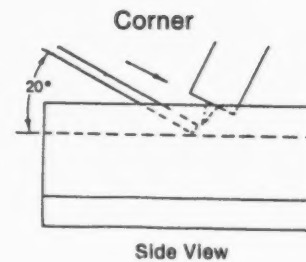
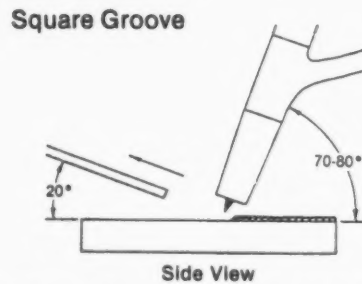
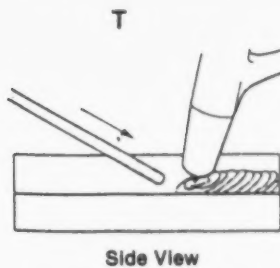
Evaluation

3 2 1 N

— — — —

— — — —

3. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.



4. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; be sure to keep the rod's end in the shielded area.
5. Advance the puddle forward while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
6. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer is complete.
7. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of the weld.
8. Place torch in a secure, safe place. Secure plate with pliers and visually inspect for good penetration with no burn-through, uniform bead width with neat appearance, and even bead ripples.
9. Ask instructor to check your work.
10. Continue making practice passes as directed by your instructor. Visually inspect each pass and have your instructor check your work.
11. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.

Average of above evaluations*

*This average is the student's final evaluation for competencies J12 and J14 and partial evaluation for J24 and J26.

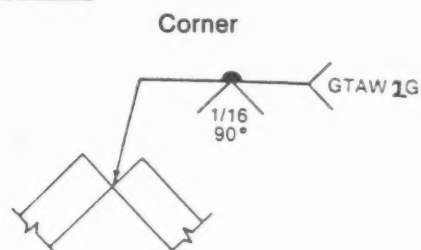
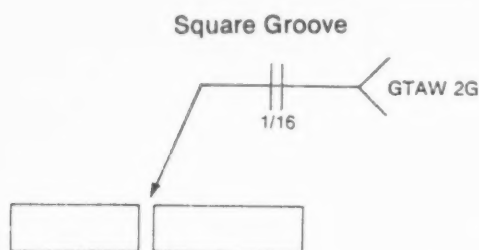
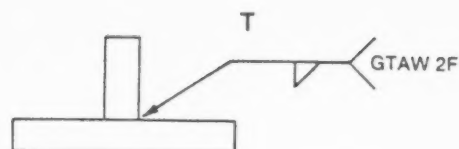
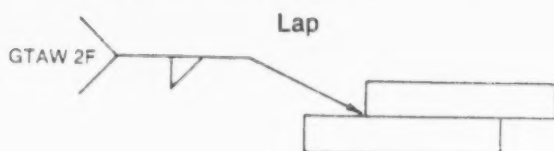
WELD JOINTS TO SPECIFICATIONS ON CARBON AND STAINLESS STEEL IN THE HORIZONTAL POSITION

Equipment:

1/16" gap wire (2G joints)

Specifications:

Joint designs and weld symbols



Filler metal: carbon or stainless steel per instructor

Tungsten: 1-2% thoriated

Shielding gas: He or Ar

Electrical: DC - high frequency set on start only

Positions: 2F, 2G

Technique: steady forward motion

Testing: visual

References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

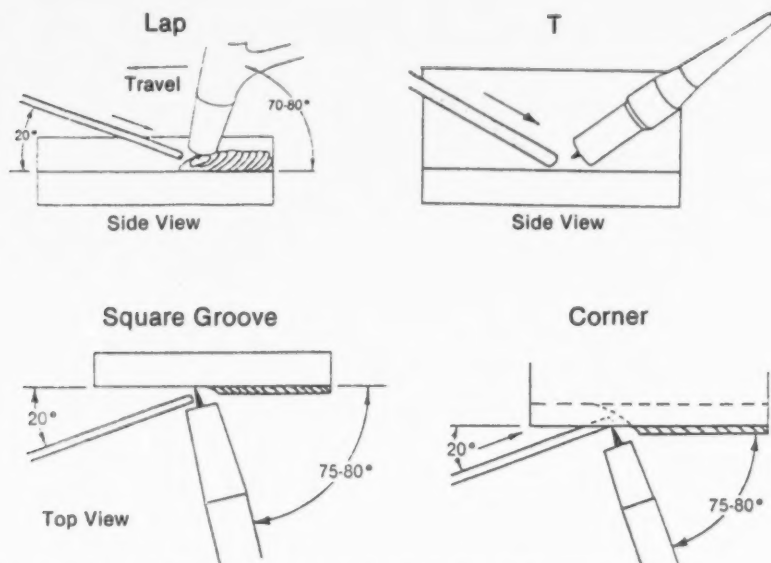
Procedure:

1. Perform JS 1.4.
2. Tack weld fillet joints. For 2G joints, use a 1/16" gap wire. Place plates in correct joint position and tack weld both ends.

Evaluation

3 2 1 N

3. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.



4. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; be sure to keep the rod's end in the shielded area.
5. Advance the puddle forward while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
6. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer is complete.
7. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of the weld.
8. Place torch in a secure, safe place. Secure plate with pliers and visually inspect for good penetration with no burn-through, uniform bead width with neat appearance, and even bead ripples.
9. Ask instructor to check your work.
10. Continue making practice passes as directed by instructor. Visually inspect each pass and have your instructor check your work.
11. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.

Average of above evaluations*

*This average is the student's final evaluation for competencies J15, J17, J27 and J29.

WELD JOINTS TO SPECIFICATIONS ON CARBON AND STAINLESS STEEL IN THE VERTICAL POSITION

Equipment:

1/16" gap wire (3G joints)

Specifications:

Filler metal: carbon or stainless steel per instructor

Tungsten: 1-2% thoriated

Shielding gas: He or Ar

Electrical: DC - high frequency set on start only

Positions: 3F, 3G

Direction of welding: vertical up (lap, square groove and corner joints)

Technique: steady forward motion

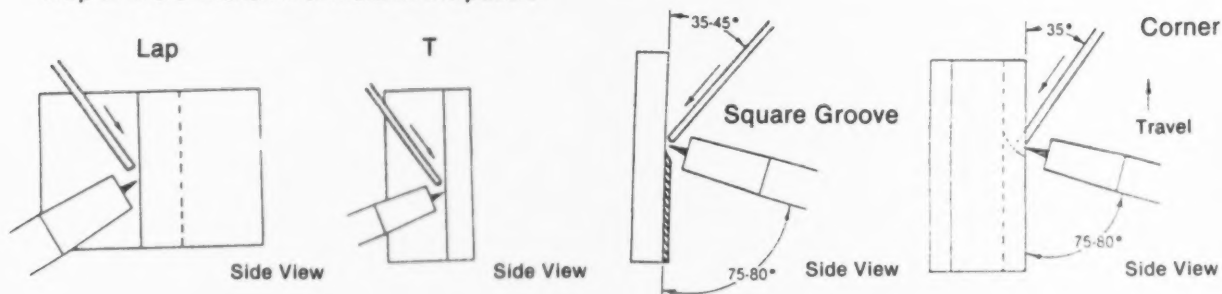
Testing: visual

References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

1. Perform JS 1.4.
2. For 3G joints, use a 1/16" gap wire. Place the plates in correct joint position and tack weld both ends.
3. For corner joints, preheat edge of plate until tack weld starts to melt. Take care that the puddle fuses to both ends of the joint.
4. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.



5. Withdraw filler rod about 1/2" from the arc so the torch and puddle can be moved in the direction of travel; keep the rod's end in the shielded area.

- | | | |
|-------------------------------|---|---------|
| 6. | Advance the puddle forward while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle. | — — — — |
| 7. | Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer is completed. | — — — — |
| 8. | Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of the weld. | — — — — |
| 9. | Place torch in a secure, safe place. Secure plate with pliers and visually inspect for good penetration with no burn-through, uniform bead width with neat appearance, and even bead ripples. | — — — — |
| 10. | Ask instructor to check your work. | — — — — |
| 11. | Continue making practice passes as directed by instructor. Visually inspect each pass and have your instructor check your work. | — — — — |
| 12. | Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — — — — |
| Average of above evaluations* | | — — — — |

*This average is the student's final evaluation for competencies J18, J20, J30 and J32.

WELD JOINTS TO SPECIFICATIONS ON CARBON AND STAINLESS STEEL IN THE OVERHEAD POSITION

Equipment:

1/16" gap wire (4G corner joint)

Specifications:

Filler metal: carbon or stainless steel per instructor

Tungsten: 1-2% thoriated

Shielding gas: He or Ar

Electrical: DC - high frequency set on start only

Position: 4F, 4G

Direction of welding: vertical up for lap, T and square-groove joints

Technique: steady forward motion

Testing: visual

References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

- | | |
|--|---------|
| 1. Perform JS 1.4. | — — — — |
| 2. For 4G corner joints, use 1/16" gap wire. Place plates in correct position and tack weld both ends. | — — — — |
| 3. Move filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle. | — — — — |
| 4. Withdraw filler rod so the torch and puddle can be moved in the direction of travel; be sure to keep the rod's end in the shielded area. | — — — — |
| 5. Advance puddle forward. Then reinsert the filler rod into the center of the molten puddle and let a drop or two of molten filler metal fill the puddle. | — — — — |
| 6. Repeat the procedure until stringer is complete. | — — — — |
| 7. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of the weld. | — — — — |
| 8. Place torch in a secure, safe place. Secure plate with pliers and visually inspect. | — — — — |
| 9. Ask instructor to check your work. | — — — — |
| 10. Continue making practice passes as directed by your instructor. Visually inspect each pass and have your instructor check your work. | — — — — |

11. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.

— — — —

Average of above evaluations*

— — — —

*This average is the student's final evaluation for competencies J21 and J23.

PREPARE A TUNGSTEN ELECTRODE FOR WELDING NONFERROUS METALS**Equipment:**

GTAW machine with accessories (DC capability)
 Personal safety clothing and equipment
 Tungsten, pure or zirconiated
 Shielding gas, as approved by instructor

Pliers
 Thick copper block
 Safety glasses

Procedure:**Evaluation****3 2 1 N**

- | | | | | |
|--|---|---|---|---|
| 1. Set up GTAW equipment as outlined (JS 1.1 and 1.2). | — | — | — | — |
| 2. Switch machine to DCRP. Place electrode in torch. Position copper block on work table. | — | — | — | — |
| 3. Turn power on. Move torch down with electrode held perpendicular to copper block until electrode tip is about 3/16" away. Depress foot control so arc jumps the gap between electrode tip and copper block. | — | — | — | — |
| 4. Allow tungsten's end to turn bright red, being careful not to contaminate the tungsten by touching the copper block. Allow electrode tip to form a ball equal to or slightly larger than the electrode's diameter. | — | — | — | — |
| 5. Increase amperage by depressing foot control slightly if the ball is too small. Continue heating until desired diameter is obtained, then release foot pedal and raise torch and electrode from the block. | — | — | — | — |
| 6. Inspect ball for correct diameter and bright, shiny appearance. Inspect for discoloration and contamination. If the tip is purple or black, the post flow of shielding gas is inadequate for the diameter of the electrode and should be increased. | — | — | — | — |
| 7. Break off improper ball with pliers and repeat the procedure; inspect. Shut down equipment. | — | — | — | — |
| 8. Ask instructor to check your work. | — | — | — | — |
| 9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — | — | — | — |

Average of above evaluations*

— — — —

*This average is the student's final evaluation for competency J4: Identify, select, shape and install tungsten electrode.

WELD JOINTS TO SPECIFICATIONS ON ALUMINUM IN THE FLAT POSITION

Specifications:

Filler metal: aluminum per instructor
 Tungsten: pure or zirconiated
 Shielding gas: He or Ar
 Electrical: AC, high frequency continuous

Positions: 1F, 1G
 Technique: steady forward motion
 Cleaning: stainless steel brush
 Testing: visual
 References: AWS A2.4-79 (4.1) and
 AWS B3.0-77 (4.2)

Procedure:

Evaluation
 3 2 1 N

- | | |
|---|---------|
| 1. Perform JS 1.4. | — — — — |
| 2. Move the filler rod into the leading edge of the molten puddle; let a drop or two of molten filler metal fill the puddle. | — — — — |
| 3. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; keep the rod's end in the shielded zone. | — — — — |
| 4. Advance the puddle forward to maintain a uniform bead width; reinsert filler rod into the center of the molten puddle, letting a drop or two of molten filler metal fill the puddle. | — — — — |
| 5. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer bead is complete. | — — — — |
| 6. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of weld. | — — — — |
| 7. Hold plate with pliers and visually inspect. Ask instructor to check your work. | — — — — |
| 8. Continue making practice passes as directed by your instructor. Visually inspect each pass and have instructor check your work. | — — — — |
| 9. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — — — — |
| Average of above evaluations* | — — — — |

*This average is the student's final evaluation for competencies J13 and J25.

WELD JOINTS TO SPECIFICATIONS ON ALUMINUM IN THE HORIZONTAL POSITION

Specifications:

Filler metal: aluminum per instructor
 Tungsten: pure or zirconiated
 Shielding gas: He or Ar
 Electrical: AC, high frequency continuous

Positions: 2F, 2G
 Technique: steady forward motion
 Cleaning: stainless steel brush
 Testing: visual
 References: AWS A2.4-79 (4.1)
 and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

- | | |
|---|---------|
| 1. Perform JS 1.4. | _ _ _ _ |
| 2. Move the filler rod into the leading edge of the molten puddle; let a drop or two of molten filler metal fill the puddle. | _ _ _ _ |
| 3. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; keep the rod's end in the shielded zone. | _ _ _ _ |
| 4. Advance the puddle forward to maintain a uniform bead width; reinsert filler rod into the center of the molten puddle, letting a drop or two of molten filler metal fill the puddle. | _ _ _ _ |
| 5. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer bead is complete. | _ _ _ _ |
| 6. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of weld. | _ _ _ _ |
| 7. Hold plate with pliers and visually inspect. Ask instructor to check your work. | _ _ _ _ |
| 8. Continue making practice passes as directed by your instructor. Visually inspect each pass and have instructor check your work. | _ _ _ _ |
| 9. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | _ _ _ _ |

Average of above evaluations*

_ _ _ _

*This average is the student's final evaluation for competencies J16 and J28.

WELD JOINTS TO SPECIFICATIONS ON ALUMINUM IN THE VERTICAL POSITION

Specifications:

Filler metal: aluminum per instructor
 Tungsten: pure or zirconiated
 Shielding gas: He or Ar
 Electrical: AC, high frequency continuous

Positions: 3F, 3G
 Technique: steady forward motion
 Cleaning: stainless steel brush
 Testing: visual
 References: AWS A2.4-79 (4.1)
 and AWS B3.0-77 (4.2)

Procedure:

Evaluation
 3 2 1 N

- | | |
|---|---------|
| 1. Perform JS 1.4. | — — — — |
| 2. Move the filler rod into the leading edge of the molten puddle; let a drop or two of molten filler metal fill the puddle. | — — — — |
| 3. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; keep the rod's end in the shielded zone. | — — — — |
| 4. Advance the puddle forward to maintain a uniform bead width; reinsert filler rod into the center of the molten puddle, letting a drop or two of molten filler metal fill the puddle. | — — — — |
| 5. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer bead is complete. | — — — — |
| 6. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of weld. | — — — — |
| 7. Hold plate with pliers and visually inspect. Ask instructor to check your work. | — — — — |
| 8. Continue making practice passes as directed by your instructor. Visually inspect each pass and have instructor check your work. | — — — — |
| 9. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. | — — — — |
| Average of above evaluations* | — — — — |

*This average is the student's final evaluation for competencies J19 and J31.

WELD JOINTS TO SPECIFICATIONS ON ALUMINUM IN THE OVERHEAD POSITION

Specifications:

Filler metal: aluminum per instructor
 Tungsten: pure or zirconiated
 Shielding gas: He or Ar
 Electrical: AC, high frequency continuous

Positions: 4F, 4G
 Technique: steady forward motion
 Cleaning: stainless steel brush
 Testing: visual
 References: AWS A2.4-79 (4.1)
 and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

1. Perform JS 1.4.	—	—	—	—
2. Move the filler rod into the leading edge of the molten puddle; let a drop or two of molten filler metal fill the puddle.	—	—	—	—
3. Withdraw filler rod about 1/2" from the arc so torch and puddle can be moved in the direction of travel; keep the rod's end in the shielded zone.	—	—	—	—
4. Advance the puddle forward to maintain a uniform bead width; reinsert filler rod into the center of the molten puddle, letting a drop or two of molten filler metal fill the puddle.	—	—	—	—
5. Repeat the procedure of inserting and withdrawing the filler rod, moving the torch, then reinserting filler rod until stringer bead is complete.	—	—	—	—
6. Stop just as you reach the end of the plate and let off on the foot control. Keep torch in place for a few seconds after end of weld.	—	—	—	—
7. Hold plate with pliers and visually inspect. Ask instructor to check your work.	—	—	—	—
8. Continue making practice passes as directed by your instructor. Visually inspect each pass and have instructor check your work.	—	—	—	—
9. Shut down equipment as previously outlined. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency J22.